915

RADIATOR THERMOMETER
FOR
AIRPLANE ENGINES

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The following publication, entitled "Radiator Thermometer for Airplane Engines," is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

PEYTON C. MARCH,
General, Chief of Staff.

OFFICIAL:

P. C. HARRIS,
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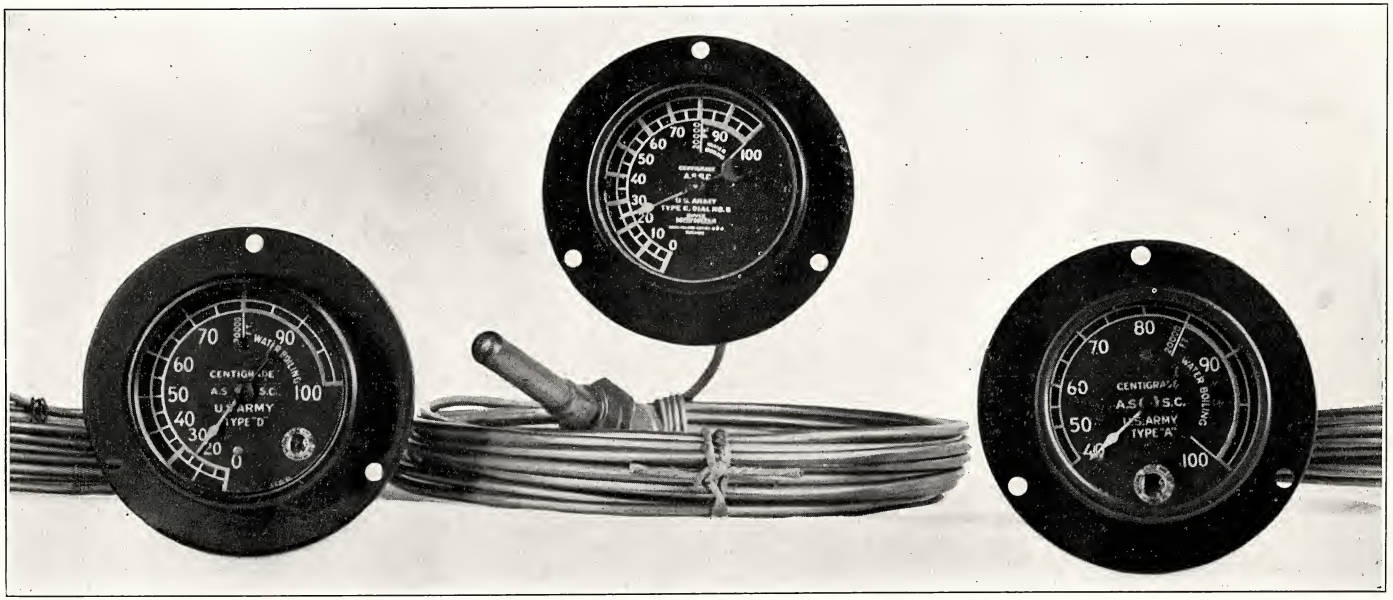

FIG. I.

RADIATOR THERMOMETERS.

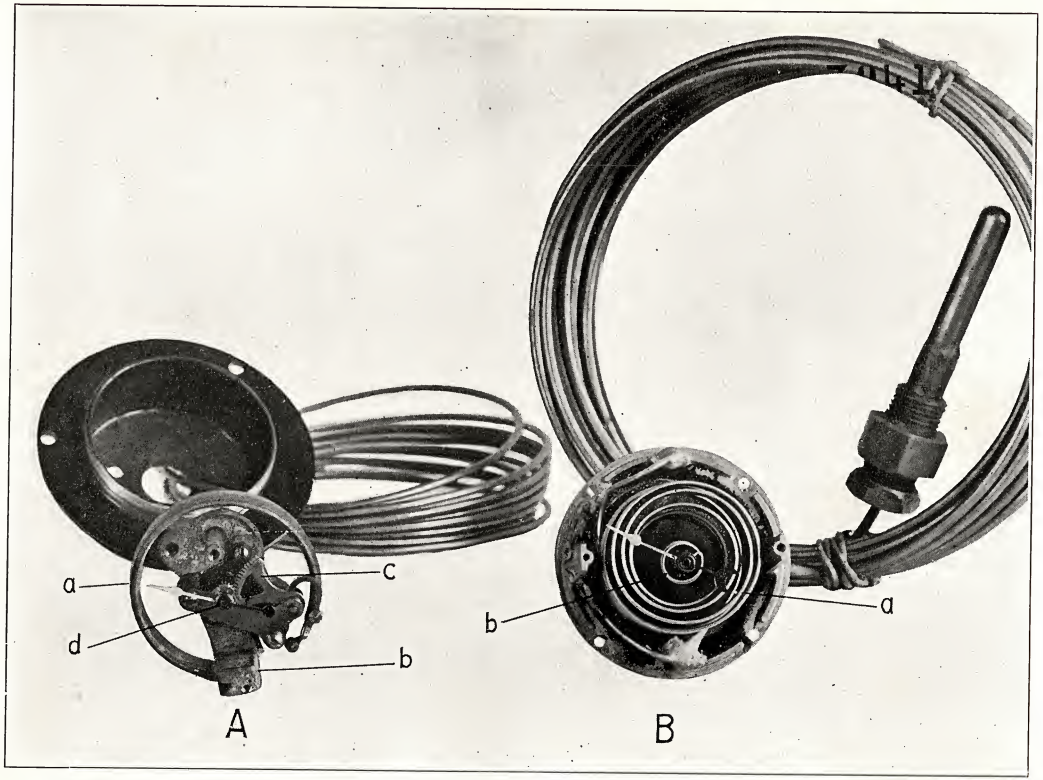

FIG. 11.

A. MECHANISM OF RADIATOR THERMOMETER, TYPE A.
B. MECHANISM OF RADIATOR THERMOMETER, TYPE C.

RADIATOR THERMOMETER.

1. USE.

This instrument indicates the temperature of the water returning to the radiator from the motor. For three reasons it is valuable to know this temperature: (1) The motor should be well warmed up before an airplane leaves the ground to insure proper circulation of the oil, proper carburetion, and uniform performance. If the motor is not sufficiently warmed up, it may miss and fail when taking off. The thermometer gives information which if heeded will eliminate this danger. (2) On a glide with the motor throttled it cools down rapidly, so that at the end of a long glide, or in cold weather even after a short one, the motor may not pick up again if too cold. The thermometer reading will give warning of this danger. (3) High-altitude motors heat up rapidly when run full speed near the ground, the temperature of the water often reaching the boiling point. Observation of the thermometer will enable the pilot to avoid this. As a rule the motor should be kept at a temperature between 10° and 30° C. below boiling. That is, near the ground the thermometer reading should be in the neighborhood of 80° C., and at an altitude of 20,000 feet, where the boiling point of water is about 80° C., the temperature should be in the neighborhood of 60° C. If the temperature is not within this range there is something wrong. At medium or high altitudes a high temperature indicates generally a loss of oil or loss of water.

2. CONSTRUCTION.

The radiator thermometer indicates temperature in the centigrade system. There are two designs in use: (*a*) The vapor pressure, and (*b*) the liquid filled. (See specification No. 27,055–A and drawing No. 030045.) Figure I shows two vapor-pressure types, A and D, manufactured by the National Gage & Equipment Co., and one liquid filled type, C, manufactured by the Boyce Motometer Co. It may be seen that in each type the thermometer consists of three parts: (*a*) An indicating head, (*b*) a capillary tube, (*c*) a cylindrical bulb.

In the first design the bulb is filled with some volatile liquid, such as ethyl ether, methyl chloride, or suphur dioxide, and the capillary tube contains only the vapor of the liquid. All air must be removed before the thermometer is filled and sealed. The pressure of the vapor is transmitted to the gage through the capillary

tubing. This vapor pressure is dependent alone on the temperature of the liquid in the bulb, provided, (1) there is always some liquid in the bulb; and (2) that there is *not* some liquid in the tubing or gage at a *higher* temperature. The first condition holds if the thermometer is properly filled, and the second is generally fulfilled when the engine is running.

In types A and D the indicator is a pressure gage of the Bourdon type, similar to the air and oil pressure gages. Figure II–A shows the details of the mechanism. The Bourdon tube *a* communicates with the capillary tube through a hollow casting *b*, which serves as a base for the mechanism and a socket extending through the case to which the capillary is fastened. The free, closed end of the Bourdon tube is connected to a sector gear *c*, which engages a pinion on the pointer shaft *d*. A hairspring on this same shaft takes up the back lash of the gears.

In the first thermometers furnished, type A, ethyl ether was used. For such the scale has a range of 40° to 100°. (In some of these the warning "20,000 feet, Water Boiling," is marked at 85° C. instead of 80° C. This has been corrected in the later instruments.) In type D methyl chloride is used. This liquid has a higher vapor pressure and makes possible a more uniform scale. The range is from 0° to 100° C. Because of the difficulty in securing pure methyl chloride, not many type D thermometers have been put into production.

The vapor-pressure types may be expected to be correct within 3° C.

Type C is a *liquid-filled* thermometer, in which the liquid is ethyl alcohol. The bulb, capillary tube, and Bourdon tube of the gage are all completely filled with alcohol under a pressure of $\frac{100 \text{ lbs.}}{\text{sq. in.}}$ at 100° C. At 100° C. this pressure increases to about $\frac{800 \text{ lbs.}}{\text{sq. in.}}$ No vapor is formed with this high pressure, but expansion of the liquid with increase of temperature causes the motion of the pointer. This expansion is nearly linear with respect to the temperature for this range, so that the scale is nearly uniform. The mechanism of the indicator is somewhat different from that of the other types. (See Fig. II–B.) The Bourdon tube *a* consists of several turns arranged in a spiral. The free, closed end is attached to one end of a helical spring *b*, the other end of which is fastened to the pointer. This helical spring *b* is a bimetallic compensator the purpose of which will be described later.

The advantages of the liquid-filled type are: (a) The more rugged construction which may be used with the high pressure, and (b) the independence of external atmospheric pressure, which does effect the vapor pressure type to some extent. However, in the liquid-filled

type the increase in volume is dependent on the temperature of the *gage* and the *capillary tubing* as well as the bulb. In order that the thermometer indicates correctly, the pressure of these should be the same at all times as their temperatures when calibrated. By marking the capillary very small the error arising from a moderate heating or cooling will be negligible for lengths up to 12 feet. Errors arising from heating or cooling of the indicator are compensated by the bimetallic coil *F*. The maximum error of this type of thermometer should not be more than 5° C.

3. INSTALLATION.

Directions for installation are furnished with the instrument by the manufacturer and should be carefully followed. Thermometers are made with different lengths of capillary tubing for different types of airplanes. An instrument with the proper length should be secured.

(1) Before the indicator can be fastened to the instrument board, the bulb and capillary tubing is passed through the hole prepared for the instrument and led toward the motor. The indicator head is then securely fastened to the instrument board.

(2) Care should be taken not to twist or kink the tubing. Near the indicator and the bulb, the tubing is covered with a spring wire sheath so as to specially protect the tubing at places where injury is most likely to occur. Between the instrument board and the motor the capillary tubing should be fastened securely to the fuselage by small clips.

(3) The bulb of the thermometer should be placed in the *outlet pipe* leading from the cylinder jackets to the radiator. If placed in the radiator or other parts of the water system, the indicated temperature will be less than that of the water coming from around the combustion chambers.

(4) Care should be used in fastening in the bulb or removing it not to twist the capillary tubing. There is no need of doing this, but sometimes a thermometer is ruined in this manner by a careless mechanic. A nut is provided which should first be turned into the outlet tube. This furnishes a seat for the flange at the outer end of the bulb. Another nut screws into the first and clamps the flange against the first. A gasket should be placed between the flange and first nut.

REFERENCES:

B. A. P. Specifications No. 27055–A.
P. E. D. Drawing No. .030045.
Aeronautical Instruments Circular No. 30, Bureau of Standards.

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